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**FLIGHT SIMULATOR FOR HYPERSONIC VEHICLE AND  
A STUDY OF NASP HANDLING QUALITIES**

**ANNUAL REPORT**

**Prepared for**

**NASA CENTER OF RESEARCH EXCELLENCE  
SCHOOL OF ENGINEERING  
NORTH CAROLINA A&T STATE UNIVERSITY**

**by**

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## **A. AREA SUMMARY**

The research goal of the Human-Machine Systems Engineering Group was to study the existing handling quality studies in aircrafts with sonic to supersonic speeds and power in order to understand information requirements needed for a hypersonic vehicle flight simulator. This goal falls within the NASA task statements:

1. **Develop Flight Simulator for Hypersonic Vehicle**
2. **Study NASP Handling Qualities**
3. **Study Effects of Flexibility on Handling Qualities and on Control System Performance**

Following the above statement of work, the group has developed three research strategies. These are:

1. To study existing handling quality studies and the associated aircrafts and develop flight simulation data characterization.
2. To develop a profile for flight simulation data acquisition based on objective statement #1 above.
3. To develop a simulator and an embedded expert system platform which can be used in handling quality experiments for hypersonic aircraft/flight simulation training.

## **B. AREA RESEARCH PROJECTS**

**Title:** Investigation of Human Response Error In A Flight Simulation Domain  
**PI:** Celestine A. Ntuen

**Title:** Investigation of A Model To Analyze Pilot/Vehicle Interaction In A Hypersonic Flight Simulator  
**PI:** Joseph M. Deeb

**Title:** A Robust Methodology For Visual Reconstruction and Surface Rendering For a NASP Cockpit Environment.  
**PI:** Jung H. Kim and Eui H. Park

## **C. PROGRAM ACTIVITIES**

To achieve objective #1, extensive data is being collected from various sources including NASA handling quality source data, U.S. Air Force handling quality handbooks, and MIT's Center For Man-Machine Flight Simulation Reports. The research outcome for this objective is in progress and is to be published under the title: "Development of Flight Database Using Handling Quality Studies". Data in this category are:

- Type of aircraft.
- Aircraft categories (e.g; sonic, hypersonic, etc.).
- Aircraft aerodynamic parameters.

- Human (pilot) characteristics.
- Environment in which handling quality are derived.
- Controllable and non-controllable variables in the flight simulation studies.
- The performance data (dependent variables) of interest.

Data collection for handling quality (HQ) was accelerated by documents made available to the group by Dr. L. Taylor of NASA Langley Research Center. While the group continues to develop conceptual models for synthetic flight simulation for hypersonic vehicle, the following drawbacks were encountered:

- It is difficult to develop the simulator from scratch. It would be better if an unused flight simulator could become available for the NASA-CORE project by NASA. This can be through surplus equipment identification from any of the NASA research centers.
- The group also needs a technical monitor from NASA. The person should have a background in developing flight training simulators and/or human factors with bias in human-machine interaction. In all meetings related to the project, the Human-Machine Group is always left out when discussions on future directions and research accomplishments are discussed. We need a collaborator to consult with in matters related to the group.

The original proposal to develop a prototype simulation model is behind by about four months due to lateness in equipment delivery. However, there is no loss time since the investigators are developing concepts and theories related to the Research program.

## D. FACULTY AND STUDENT PARTICIPATION

### Faculty participants

Faculty	Department Affiliation	Ethnic Backg.	Teaching Interest	Research Interest	CORE Responsibility	No. of Students Advised
Celestine A. Ntuen	Industrial Engineering	Black	Human-Machine Interaction Systems Design Methodology	Human-Machine Systems, Artificial Intelligence and Reliability	Team Leader	2
Eui H. Park	Industrial Engineering	Asian	Simulation, Quality Control Manufacturing	Manufacturing Systems, Robotics & Quality Control	Team Member	-
Joseph M. Deeb	Industrial Engineering	White	Human Factors, Ergonomics and Manual Material Handling	Human Factors & Ergonomics	Team Member	1
Jung H. Kim	Electrical Engineering	Asian	Computer Vision & Signal Processing	Signal Processing and Expert Systems	Team Member	-

## NASA-CORE (HUMAN-MACHINE SYSTEMS GROUP)

### Student Participant's Profile

Research Assistant	Citizenship/ Ethnic Group	Address	Major	Classification	GPA	Advisor
Woodrow Winchester	U.S.A. (Black)	912 Fairgreen Road Greensboro, NC 27410	Industrial Engineering	Senior*	3.15	J. Deeb
Christopher Geiger	U.S.A. (Black)	408-C Savannah Street Greensboro, NC 27406	Industrial Engineering	Senior*	3.05	C. Ntuen
Erika Mansfield	U.S.A. (Black)	2920-B Cottage Place Greensboro, NC 27455	Industrial Engineering	First Semester Graduate Student	3.5 in UG	C. Ntuen

The three students work as a team on a project entitled: "The Development of Flight Simulation Database Using Handling Quality Studies". An object-oriented database using functional nets is used as an investigative tool. The paper has been submitted for conference presented by the students.

## E. PROGRAM IMPACT AND FINANCIAL REPORT

### Project Impact Statement

1. Two African-American students mentored and encouraged in the senior undergraduate year to consider graduate school. All two students will be full time graduate students in Industrial Engineering beginning Spring 1993.
2. Two African-American students have been admitted to graduate program in Industrial Engineering beginning Spring 1993 (one female and one male).
3. As a part of our pipeline recruitment process, two senior Industrial Engineering students will join the research team in January of 1993.
4. There are 146 undergraduate students in the Department of Industrial Engineering of which 124 students (or 85%) are African-American. The graduate program has 40 students, of which 36 students (or 90%) are African-American.
5. Enrollment prediction for the next five years in Industrial Engineering

Year	Undergraduate	Graduate	Total
1993	146	40 (MSIE)	186
1994	150	40 (MSIE)	190
1995	155	45 (MSIE)	200
1996	155	50 (MSIE + PH.D)	205
1997	160	50 (MSIE + PH.D)	220

With this growth prediction, it is expected that five full time faculty (teaching and research) and at least one research faculty will be needed.

## **Publications**

1. Kim, J.H., Yoon, S.H., Park, E.H. and Ntuen, C.A., Recognition of Partially Occluded Threat Objects Using the Annealed Hopfield Network, Proc. of SPIE OE/Technology Conference, Boston, Massachusetts: 15-20 Nov., 1992.
2. Brooks, T.D., and Kim, J.H., An Approach to Three-Dimensional Object Recognition Using A Hybrid Hopfield Network, Submitted, IEEE Southeastcon '93, Charlotte, N.C.
3. Knight, D.D. and Kim, J.H., Object Identification Using a Reconstructed Surface of Concealed Object, Submitted, IEEE Southeastcon '93, Charlotte, N.C.
4. Ntuen, C.A., Information Theoretic Models of Human-Machine Interaction, Submitted, International Journal for Information Sciences.
5. Ntuen, C.A., Park, E.H., Deeb, J.M., Geiger, C., Mansfield, E. and Winchester, W. The Development of Flight Simulation, Database Using Handling Quality Studies, Submitted, 15th Annual Conference on Computers and Industrial Engineering, Cocoa Beach, FL, March 8-10, 1993.
6. Ntuen, C.A., A New Approach To Modeling Human Response Errors In Synthetic Flight Simulator Domain, Submitted, 15th Annual Conference on Computers and Industrial Engineering, Cocoa Beach, FL, March 8-10, 1993.
7. Johnson, A.R., Ntuen, C.A. and Park, E.H., An Experimental Study of Human Interpretation of Computer Generated Image Data, Submitted, 15th Intl. Conference on Human-Computer Interaction/9th Japanese Symposium on Human Interface, Orlando, FL, August 8-13, 1993.

## Area Financial Report

### BUDGET FOR THE FIRST YEAR

ITEMS	ALLOCATION	ACTUAL EXPENSES	%OF SPENDING
1. Investigators' Salaries <sup>1</sup>	\$ 40,500	\$ 34,309	85 %
2. Secretary Salary	\$ 1,500	\$ 0	0 %
3. Student Assistanship <sup>2</sup>	\$ 7,500	\$ 4,473	60 %
4. Fringe Benefits <sup>3</sup>	\$ 10,800	\$ 9,308	86%
5. Indirect Costs <sup>4</sup>	\$ 27,225	\$ 21,330	78%
6. Direct Costs	\$ 37,288	\$ 30,362	81 %
- Scientific Equipment <sup>5</sup>	\$ 24,688	\$ 22,193	95 %
- Lab/Office Supplies	\$ 2,000	\$ 852	43 %
- Contracted Services <sup>6</sup>	\$ 500	\$ 500	100 %
- Other Supplies	\$ 1,000	\$ 0	0 %
- Travel Expenses <sup>7</sup>	\$ 6,000	\$ 4,104	68 %
- Printing <sup>8</sup>	\$ 400	\$ 0	0 %
- Postage	\$ 200	\$ 0	0 %
- Books/Journals <sup>9</sup>	\$ 1,500	\$ 903	60 %
- Tuition/Scholarships <sup>10</sup>	\$ 2,000	\$ 1,090	55 %
<b>TOTAL</b>	<b>\$ 125,093</b>	<b>\$ 99,516</b>	<b>80 %</b>

- NOTE:**
1. Investigators' release times for this project are as follows:
    - Dr. Celestine Ntuen (1 man-month)
    - Dr. Joseph Deeb (3.625 man-months)
    - Dr. Eui Park (0.45 man-month)
    - Dr. Jung Kim (1 man-month)
  2. This project successfully motivated three African-American students to pursue their advanced degrees in Industrial Engineering. Ms. Erika Mansfield started her graduate study in Fall of 1992. Both Mr. Woodrow Winchester and Mr. Christopher Geiger are senior students and will join the Industrial Engineering graduate program in Spring of 1993.
  3. 24 % of Items 1 and 3, and 7.65% of Item 3.
  4. 55 % of Items 1, 2 and 3.
  5. Four equipment are purchased as follows to implement this project.
    - DT Image Grabber
    - MATRIX<sub>x</sub> Simulation Software

- SUN SPARCstation 10
  - HP LaserJet IIP
6. This was used to build a pilot seat simulator.
  7. All investigators visited NASA-Langley Research Center to discuss our research direction and to collect research materials in May 1992. Drs. Ntuen and Deeb attended a workshop in June on "Fundamentals of Flight Simulation" organized by MIT.
  8. Library copy cards were purchased for necessary materials to be copied.
  9. Necessary books to implement this project were purchased.
  10. These funds were used to support tuition fees for Mr. Winchester and Mr. Geiger.

### **Student Support and Equipment Purchased**

#### **STUDENT SUPPORT**

<b>Name</b>	<b>SUMMER 1992</b>	<b>FALL 1992</b>
<b>Woodrow Winchester</b>	<b>20 hrs/wk</b>	<b>15 hrs/wk</b>
<b>Christopher Geiger</b>	<b>10 hrs/wk</b>	<b>15 hrs/wk</b>
<b>Erika Mansfield</b>	<b>-----</b>	<b>20 hrs/wk</b>

#### **EQUIPMENT PURCHASED**

<b>EQUIPMENT</b>	<b>PRICE</b>	<b>DELIVERY STATUS</b>
<b>DT Precision Frame Grabber</b>	<b>\$ 2,661.00</b>	<b>June 1992</b>
<b>MATRIX<sub>x</sub></b>	<b>\$ 1,054.70</b>	<b>not yet</b>
<b>SUN SPARCstation 10</b>	<b>\$ 19,197.66</b>	<b>not yet</b>
<b>HP LaserJet IIP/DeskJet</b>	<b>\$ 1,534.00</b>	<b>not yet</b>
<b>TOTAL</b>	<b>\$ 24,447.36</b>	

## Students and Faculty Profiles

### Research Assistants' Profile

Research Assistant	Citizenship	Address	Major	Classification	GPA	Advisor
Woodrow Winchester	U.S.A.	912 Fairgreen Rd. Greensboro, NC 27410	Industrial Engineering	Senior*	3.15	J. Deeb
Christopher Geiger	U.S.A.	408-C Savannah St. Greensboro, NC 27406	Industrial Engineering	Senior*	3.05	C. Ntuen
Erika Mansfield	U.S.A.	2920-B Cottage Place Greensboro, NC 27455	Industrial Engineering	Graduate Student	3.25 in UG	C. Ntuen

### Investigators' Profile

Investigator	Citizenship	Address	Research Interests
Dr. Celestine Ntuen	Nigeria (Permanent Resident in U.S.A.)	3101 Paddington Street Greensboro, NC 27406	Human-Machine Systems, Artificial Intelligence, & Reliability
Dr. Eui Park	U.S.A.	1623 Helmwood Dr. Greensboro, NC 27411	Manufacturing Systems, Robotics, & Quality Control
Dr. Joseph deeb	U.S.A.	1715 Swannanoa Dr. Greensboro, NC 27410	Human Factor/Ergonomics, & Manual Material Handling
Dr. Jung Kim	U.S.A.	2711 New garden Rd. Greensboro, NC 27408	Signal Processing, & Expert Systems

NOTE: \* They will be in the IE Graduate Program from the Spring semester of 1993.